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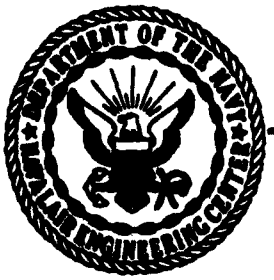

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NAVAL AIR ENGINEERING CENTER

REPORT NAEC-92-145

LEVEL II

NICKEL-CADMIUM BATTERY CHARGER

Handling & Servicing/Armament Division
Support Equipment Engineering Department
Naval Air Engineering Center
Lakehurst, New Jersey 08733

23 FEBRUARY 1981

Interim Report for Period October 1978 to October 1980
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NAEC-92-145

NICKEL-CADMIUM BATTERY CHARGER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains information relevant to the support of mini nickel-cadmium batteries (0 to 5 Amp-hr) utilized in the Fleet. Initial reports indicated that these batteries were not supported by an approved charger/analyzer. A thorough investigation of this allegation concluded that all complaints concerning the lack of support of these batteries have been corrected and no documentation has been found to indicate otherwise. It was also determining that pulse charging warrants further investigation as a possible charging technique to be applied to these batteries.

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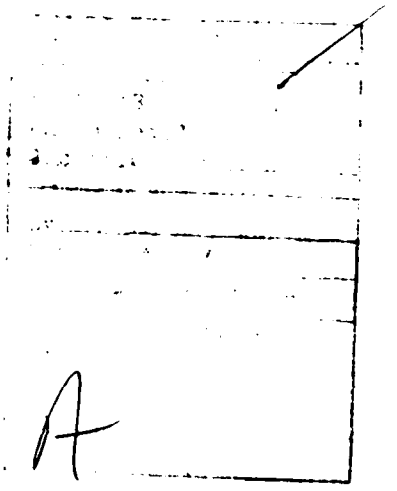
SUMMARY

A. GENERAL. This program stemmed from Fleet reports that a lack of mini-battery servicing procedures/equipment had resulted in expensive, rechargeable mini-batteries being discarded every 28 to 56 days by user activities. An investigation into this situation revealed that these batteries are supported either by Naval Weapons Support Center (NAVWPNSUPPCEN) Crane or by the maintenance manuals for the specific piece of equipment which they are supporting.. This report documents the results of the investigation and also provides information on the future direction of this program, which is to analyze the credibility of pulse charging techniques for the subject batteries.

B. PROCEDURES AND RESULTS. An attempt was made to analyze the alleged problems in the Fleet relating to the maintenance/service of mini nickel-cadmium batteries. The ensuing investigation revealed that the batteries were supported but problems exist in the areas of maintenance procedures clarity, lack of trained personnel, inadequate facilities, shortage of replacement parts, and the lack of design standards which results in a wide variety of new battery designs. An offshoot from the above analysis was that pulse charging methods warrant further study. Subsequent work will follow along those lines.



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I. INTRODUCTION

The basis of this program is a series of complaints from the Fleet dating back to the early 1970's that there were many nickel-cadmium (ni-cd) batteries used aboard aircraft which were not supported by an approved charger/analyzer, and that improper servicing would shorten the life of the battery and cause failures resulting in loss of mission, plane, and life.

Subsequently an investigation of these problems was initiated at The Naval Air Engineering Center (NAVAIRENGCEN). This report contains information relevant to the above investigation and the results obtained therein. The future course to be followed by the program is identified, with anticipated results pointed out.

II. OBJECTIVES

The initial objective of this effort was to gather information relevant to the allegations that many mini nickel-cadmium batteries in the Fleet were not supported by an approved charger/analyzer. A secondary objective, which developed later in the program, was to initiate an investigation of pulse charging as an advantageous method of charging the batteries in question.

III. PROCEDURE

A. BACKGROUND

1. The genesis of this effort goes back to an NBC-1/Mini Battery Charger Meeting, held on 8-9 January 1974, at the NAVAIRENGCEN, Philadelphia, PA. It was brought forth that the lack of mini-battery servicing procedures/equipment had resulted in expensive ($25 to $200), rechargeable mini-batteries being discarded by user activities every 28 to 56 days. It was further indicated that on two occasions aircraft had been grounded because of a lack of batteries, and that the cost of replacing the mini-batteries in lieu of recharging them was estimated at an excess of a million dollars a year.

2. The topic of inadequate servicing equipment for mini nickel-cadmium batteries came up again at the Second Annual Aviation GSE Conference on 10-11 November 1976. The current 4-year program to investigate this situation began in FY-79.

B. APPROACH

1. Since the beginning of the project, half of the original listing of 40 batteries have been eliminated as not conforming with the definition of mini ni-cd batteries. As originally defined, the mini ni-cd battery has an unlimited number of cells and falls into the range of zero-to-five ampere hours capacity. The investigation began by locating the operating and maintenance manuals for the equipment using these batteries, to determine the adequacy of maintenance procedures which were available. Results of this effort indicated that:

a. General-purpose batteries designated by military specification (MS) numbers are currently covered by maintenance procedures written by the cognizant field activity (CFA) at NAVWPNSUPPCEN, Crane, Indiana.

b. Batteries used in avionics, communication, and electronic test equipment are covered by maintenance procedures outlined in the operating and maintenance manuals for the specific equipment.

2. A survey of Naval Air Rework Facility, Naval Aviation Engineering Services Unit, and Aircraft Intermediate Maintenance Department (NAVAIREWORKFAC, NAESU, and AIMD) activities indicated that all complaints concerning the lack of support of these batteries have been corrected. No documentation has been found to indicate otherwise. Sporadic occurrences of maintenance problems are attributable to a lack of technical training, a relatively short tour of duty for trained personnel, and a lack of facilities. A concern was expressed about current maintenance practices and the apparent weakness in basic design. Several suggestions were brought forth on how to reduce operating cost and improve maintenance effectiveness by improving the design of batteries and charging equipment. AIMD activities were consistent in their reports that there were no existing maintenance problems, and that the existing maintenance procedures were adequate for their purposes.

C. ANALYSIS

1. Several conclusions could be drawn from the initial phase of this investigation as delineated below:

a. There are no unsupported mini ni-cd batteries in the Fleet.

b. There is a large quantity of peculiar chargers in the system.

c. No single, common charger/analyzer is capable of supporting the entire range of mini ni-cd batteries.

d. Published maintenance procedures are sometimes vague.

e. There is a lack of trained personnel due to:

(1) A reluctance of commanders to release personnel to attend schools.

(2) The relatively short tour of duty of trained personnel.

f. Facilities for maintaining batteries are not always adequate due to:

(1) The lack of air-conditioned shops restricts the operation of equipment during temperature extremes.

(2) Supplemental equipment for specific tests is not always available.

g. Availability of replacement parts is a periodic problem.

h. There is a lack of design standards which results in a wide variety of new battery designs.

3. To gain further insight into the support requirements of mini ni-cd batteries, it would be advisable to look at the more familiar aircraft batteries described in NAVAIR 17-15BAD-1. This manual lists a total of 17 batteries used in Navy aircraft. Each of these batteries is housed in a similar container and is made up of 19 or 20 vented, rectangular cells. All batteries are terminated by one of a choice of two connectors. The capacities range from 4 to 31 ampere hours. Since the nature of the loads on these batteries is identical, the maintenance procedures are similar. They are all supported by a single, common charger/analyzer, the NBC-1/A.

3. Of the 23 mini ni-cd batteries included in this program (see appendix A), 8 are provided with peculiar chargers, and others are supported by built-in chargers furnished as part of the basic equipment.

4. Looking at the differences among these batteries, it is understandable why a common charger/analyzer has not yet been developed:

a. The number of cells varies from 1 to 68.

b. Capacities vary from 0.225 to 5.0 ampere hours.

c. Functional tests for some batteries require discharge loads up to 30 amperes.

d. Many batteries have unique terminations.

e. Access to individual cells is generally limited, and in some cases, nonexistent.

f. The number of components within the battery varies widely. They include up to:

(1) 68 active cells

(2) 2 passive cells

(3) 6 thermistors

(4) 2 thermostats

(5) 4 fuses

(6) 3 heater blankets

g. There is a wide variety of cell types, each carrying different charging recommendations by the manufacturer. They include:

(1) Flooded rectangular cells

(a) Vented

(b) Sealed

(2) Button cells

(3) Sealed cylindrical cells

(a) Standard

(b) Quick charge

(c) Fast charge

5. If it were decided to develop a common charger/analyzer for this family of mini ni-cd batteries, it would be necessary to consider the following parameters:

a. A 100/1 voltage range (1-100V).

b. A 1000/1 charge current range (0.02-20 amps).

c. A 150/1 discharge current range (0.2-30 amps).

d. Constant current charge.

e. Pulsed current charge, with and without pulsed current discharge.

f. Trickle charge.

g. Constant current discharge for capacity tests.

h. Pulsed current discharge for functional tests.

i. Cell scanning.

j. Cell matching procedures for cell replacement.

k. Thermistor resistance testing.

l. Thermostat continuity testing.

m. Temperature control and measurement.

n. Fuse continuity testing.

o. Coulometer performance evaluation.

p. Heater current measurement.

q. Connector and wiring continuity testing.

r. Provisions for soldering and welding connector and cell terminations.

IV. DISCUSSION OF RESULTS

Based on the previous anaylsis, future direction of the project hinges on the evaluation of existing maintenance procedures, equipment, personnel, facilities, and replacement parts with respect to the cost effectiveness of any recommended changes to current practices. Some of the possible choices are outlined below:

A. Based on the evaluation of results from the past effort it may be reasonable to conclude that sufficient problem areas do not exist, and that further work on this project would not be justified.

B. Sufficient improvement in the effectiveness of battery maintenance can be realized by sending more technicians through technical schools.

C. More effective utilization of trained personnel can be realized by extending the tours of duty of existing technicians.

D. Effectiveness of battery shops can be improved by upgrading existing facilities and providing more equipment.

E. NAVAIR 17-15BAD-1, Naval Aircraft Storage Batteries, can be expanded to include a description of sealed ni-cd batteries and maintenance procedures based on existing charger(s)/analyzer(s).

F. Battery design standards can be introduced to minimize the quantity of different batteries being introduced into the system.

G. Existing peculiar chargers can be replaced by a single unit or a small family of common charger(s)/analyzer(s).

H. Pulse charging methods can be further investigated as an advantageous method of charging mini ni-cd batteries.

V. CONCLUSIONS AND RECOMMENDATIONS

A. The results of this effort to date indicate that all complaints concerning the lack of support of the mini ni-cd batteries have been corrected. General-purpose batteries which have been assigned MS numbers are currently covered by maintenance procedures written by the cognizant field activity at NAVWPNSUPPCEN, Crane, Indiana. Batteries which are part of an avionics, communication, or electronic test equipment system are covered by maintenance procedures outlined in the operating and maintenance manuals for the specific equipment.

B. There are problems with a lack of: trained personnel, adequate facilities for maintaining batteries, replacement parts, design standards which results in a wide variety of new battery designs.

C. An extension of this program is pulse charging techniques. Various papers on the topic suggest that it can:

- Extend battery life
- Increase charge acceptance
- Correct for memory effect
- Decrease maintenance time
- Increase the time between maintenance cycles
- Provide a useful state-of-charge indication

D. An investigation of pulse charging methods is the recommended future direction of this program. If this technique proves to be worthwhile and more advantageous than constant current charging, it should be addressed accordingly in NAVAIR 17-15BAD-1. Possible revisions/modifications to the NBC-1 charger may be appropriate or an entire new charger(s)/analyzer(s) breadboard design may be more practical.

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APPENDIX A - MINI NICKEL-CADMIUM (NI-CD) BATTERIES

BATTERY PN	BATTERY FSCM	VOLTS	CAPACITY AMP HRS	CELL PN	CELL FSCM	EQUIPMENT (USED WITH)	EQUIPMENT SUPPORTED	AIRCR
T04193G1	97953	38	1	41-B0011002 28R125 28-5113	GE GULTON SONOTONE	AN/ASN-84 NAVIGATIONAL SET, INERTIAL		P-3
551-12227	90634	26.4	1.1	551-13176 (ACTIVE) 551-12249 (PASSIVE)	90634 90634	AN/ASN-90 MEASURING SET, INERTIAL		A-7E
681310-1	06481	28	1	39123 972258-1	06481	AN/ASN-92 NAVIGATIONAL SET, INERTIAL		E-2, F- A-6
784320-1	06481	30	5.0			AN/ASN-102 NAVIGATIONAL SET, INERTIAL		P-3
158750-01-01 BA-597	35351	35/25	1	39432-1 39432-2 4VR1-2	74025 09052 19209	AN/ASN-124 DISPLAY SET, INERTIAL		P-3 DERIVAT
MS3319-1 27434	74025	24	0.75	MS90321-86 C13882		EMERGENCY THROTTLE		US-2,A HH-2C, SH-2D,F
MS3337-2 5M1004-3 18HV01-1C11546 C11546	96906 76301 09052	25.6	0.5			AN/ALQ-91 TRANSCEIVER, EW		F-4
MS3346-1 D11587		24	2.5	MS90321-87 C11661				RF-8G, A-7A,B,
MS17334-1 27177 C-11150	90634 74025 90634	24	0.4	R070 B7427 C11130 (COUL.)		SPIN ASSIST, LIFE RAFT		EA-6B S-2E,G C-1A, US-2D
32-031295-01	15280	7.5	7	70SCL SIZE F	88220	AN/ASM-456 TEST SET	AN/ALR-45 COUNTER-MEASURES SET	F-14,R A-6, K F-4, A F-8, H
37615	55933	12	1			450T 650T TEST SET	AN/APN-70B LORAN	P-3,T- C-130A C118B, P-2, A
666193-707 17V0-75CP 10100000	12436 09052 PWR INC	20.4	1			AN/ARM-53 RADIO TEST SET	SONOBUOY RADIO RECEIVER	A-7, F S-2G,

ICKEL-CADMIUM (NI-CD) BATTERIES

M	VOLTS	CAPACITY AMP HRS	CELL PN	CELL FSCM	EQUIPMENT (USED WITH)	EQUIPMENT SUPPORTED	AIRCRAFT	CHARGER	NAVAIR MANUAL
3	38	1	41-B0011D02 28R125 28-S113	GE GULTON SONOTONE	AN/ASN-84 NAVIGATIONAL SET, INERTIAL		P-3	BA-36	17-5DE-3 01-75PA-4-8
4	26.4	1.1	551-13176 (ACTIVE) 551-12249 (PASSIVE)	90634 90634	AN/ASN-90 MEASURING SET, INERTIAL		A-7E	QEL-1916-1	05-35EAB-1
1	28	1	39123 972258-1	06481	AN/ASN-92 NAVIGATIONAL SET, INERTIAL		E-2, F-14, A-6	251446-1	05-35KAA-50 17-75-22
1	30	5.0			AN/ASN-102 NAVIGATIONAL SET, INERTIAL		P-3		None
1	55/25	1	39432-1 39432-2 4VR1-2	74025 09052 19209	AN/ASN-124 DISPLAY SET, INERTIAL		P-3 DERIVATIVE	LT5743-01-01	16-30ASN124-1
5	24	0.75	MS90321-86 C10882		EMERGENCY THROTTLE		US-2,A,B,C HH-2C,D SH-2D,F		17-15BAD-1
6 1 2	25.6	0.5			AN/ALQ-91 TRANSCEIVER, EW		F-4		17-15BAD-1
	24	2.5	MS90321-87 C11661				RF-8G, A-7A,B,C,E		17-15BAD-1
5	24	0.4	R070 B7427 C11130 (COUL.)		SPIN ASSIST, LIFE RAFT		EA-6B S-2E,G C-1A, E-1B US-2D		17-15BAD-1
	7.5	7	70SCL SIZE F	88220	AN/ASM-456 TEST SET	AN/ALR-45 COUNTER-MEASURES SET	F-14,RA-5C A-6, KA-6 F-4, A-7, F-8, H-3	-	16-30ASM456-1
	12	1			450T 650T TEST SET	AN/APN-70B LORAN	P-3,T-29B C-130A,GD C118B,C121 P-2, A-3		17-15LAA-20
NC	20.4	1			AN/ARM-53 RADIO TEST SET	SONOBUOY RADIO RECEIVER	A-7, F-4 S-2G, S-3	HP-629A	16-30ARM53-1,2

BATTERY PN	BATTERY FSCM	VOLTS	CAPACITY AMP HRS	CELL PN	CELL FSCM	EQUIPMENT (USED WITH)	EQUIPMENT SUPPORTED	AIRCRAF
178AS200 17885200 SE0647274 BB-705/U	30003 83740	12.5	0.55			AN/AWM-54	ACFT FIRING CIRCUIT	A-7E
016-0066-02	80009	24	6			422 TEK. SCOPE		
BB620-URT26 102217 10114	80058 36452	5.2	2			CONTROL DISPENSER	AN/ASH-20 RECORDER/ LOCATOR, FLIGHT	E-2, C-2 P-3, C-1
BA1109/URT26 102217,10114-1 R200SPECIAL 102512	 36452 32517 99564	1.2	2			RADIO BEACON, SHUTOFF	AN/ASH-20 RECORDER/ LOCATOR, FLIGHT	E-2, C-2 P-3, C-1
GC3	11477	12	1.2	41B004AA17	GE	AN/GRC-164		
NLN-6238A N64 14287	83740 83740 09052	14.4	0.5	CH500		HT-200 AN/PRC-91		
-		1.2	0.81	S102 S102 R070 750SC	55933 74025 09052 31741	EMERGENCY LIGHTS		CH-53A,D
-		1.25	3.5	26042-5	74025	321/USM-211 TEKTRONIX SCOPE		P-3A,B,C
NLN-6761A	01537	15	0.45					
NLN-6682A	01537	15	0.225					
1420-0011	28480	1.25	4					

M	VOLTS	CAPACITY AMP HRS	CELL PN	CELL FSCM	EQUIPMENT (USED WITH)	EQUIPMENT SUPPORTED	AIRCRAFT	CHARGER	NAVAIR MANUAL
3 0	12.5	0.55			AN/AWM-54	ACFT FIRING CIRCUIT	A-7E	PP6681/ AWM	16-30AWM54-2
9	24	6			422 TEK. SCOPE				16-45-1161
8 2	5.2	2			CONTROL DISPENSER	AN/ASH-20 RECORDER/ LOCATOR, FLIGHT	E-2, C-2 P-3, C-130	BCU-12E/ CBC-1	16-30ASH20-1 16-45-1632
2 7 4	1.2	2			RADIO BEACON, SHUTOFF	AN/ASH-20 RECORDER/ LOCATOR, FLIGHT	E-2, C-2 P-3, C-130	BCU-12E/ CBC-1	16-30ASH20-1 16-45-1632
7	12	1.2	41B004AA17	GE	AN/GRC-164				NAVELEX 0907-376-0010
9 0 2	14.4	0.5	CH500		HT-200 AN/PRC-91				
	1.2	0.81	S102 S102 R070 750SC	55933 74025 09052 31741	EMERGENCY LIGHTS		CH-53A,D		01-230HMA4-9
	1.25	3.5	26042-5	74025	321/USM-211 TEKTRONIX SCOPE		P-3A,B,C		01-75PAA-4-13
	15	0.45							
	15	0.225							
	1.25	4							

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